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Fine Purification of Gas in Bag Type Frame Filters

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FINE PURIFICATION OF GAS IN BAG TYPE FRAME FILTERS

[Tonkaya Ochistka Gaza v Karkasnykh Rukavnykh Fil'trakh]

by

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Experimental studies on developing the design and optimal working conditions of equipment for the fine purification of working glass from suspended dust particles have been carried out at an experimental facility with a capacity from 1 to 2.6 m^3/sec.

The bag filter (Fig. 1) consists of four parallel-connected sections. Regeneration of the bag is provided by reverse blowing of the purified gas (without rapping of the bags). Hermetic dampers are provided for switching off a section for regeneration, and also for feeding purified gas for reverse blowing; on attainment of a specific hydraulic drag the dampers

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are switched on from a remote-control panel. Each filter section has a hopper. Collected dust is unloaded periodically. The total filtration surface area is 124 m^2. The filter section is made in the form of a metal casing 1 m in diameter and 4 m in height. Within the body are located 88 frame filtering elements.

The frame of a filtering element is made of angle bars, the four ledges of which form edges at an angle of 90° (Fig. 2); over the edges is stretched a No 4.5 metal mesh. The bottom of the filtering element is welded with an end-face cover. In the upper gas-distributing screen the filtering element is sealed with a threaded connecting piece. Cord asbestos with graphitized impregnation is used as the gasket material for the seals.

In selecting the optimal filtering materials resistant to corrosive (strong alkali medium) gases and affording high collection efficiency, experimental studies were conducted on bags of three types of fabric: ChSh baize, nitron, and glass cloth.

The filter cloth was made of sarge weave 2 x 2 nitron with limited one-sided hackle of nap (the threads of the warp and woof were made of staple fiber).

Grade TSSNF-O glass cloth was treated with 1.5 percent aqueous solution of GKZh-94 organosilicon liquid. The density of the cloth in the warp and woof was 21/21, and the weave was irregular four-heald satin. The strength of the cloth in the warp was 901.6 N (92 kg) and the moisture content of the glass was 0.02 percent.

As we can see from Fig. 3, the hydraulic drag of TSSNF-O glass cloth is considerably higher than the drag of cloth made of nitron and ChSh baize. For example, with a gas load of $9 \cdot 10^{-3}$ $m^3/m^2 \cdot$ sec (0.5 $m^3/m^2 \cdot$ min), the hydraulic drag of glass cloth is 50 N/m^2 (5.02 mm H_2O).

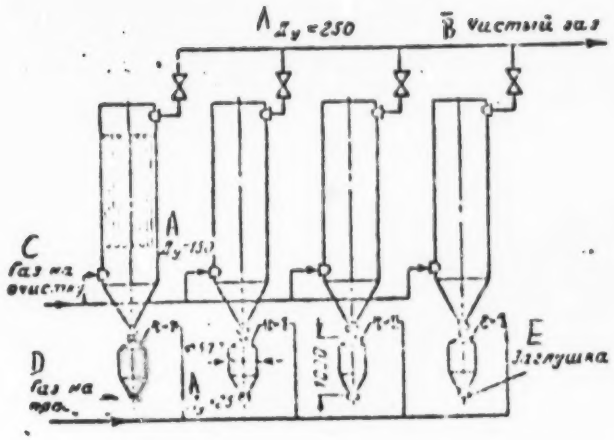

Fig. 1. General view of filtering facility

KEY: A — D_c [c = collecting]

B — Purified gas

C — Gas for purification

D — Gas for sampling

E — Plug

From Fig. 3 we also see that the hydraulic drag increases as the load for filtration is raised and is 200 N/m^2 (20.4 mm H_2O) for $q = 3.4 \cdot 10^{-2}$ $m^3/m^2 \cdot$ sec ($2\ m^3/m^2 \cdot$ min).

The collection efficiency of the bag filter was calculated by the dust concentration at the inlet and outlet from the bag filter. The concentrations of dust and the ionizing additive (potash) were measured by the NIIOGAZ method using the technique of internal filtration in glass filters packed with 3-micron diameter glass fiber.

The dispersion composition of potash dust was determined by the method in [1, 2]. The particle sedimentation rate was determined in an ultramicroscope, and the projective radii were calculated from the areas of projection measured under a MBI-3 optical microscope, by the formula

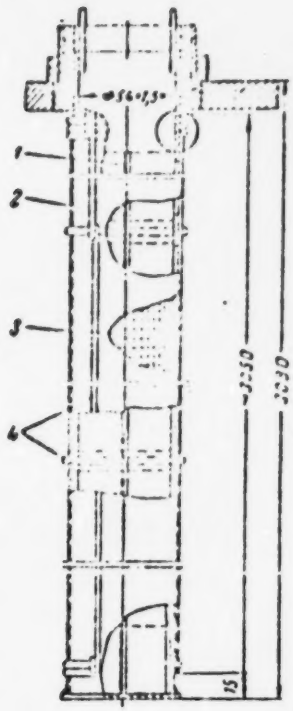

Fig. 2. Filtering element

1 -- angle bar; 2 -- bag;

3 -- meshing; 4 — twist

joint.

$R_a = 0.56\ n^{-1} F^{0.5}$ (n is the power of magnification and F is the area of the projection of the particle on the substrate).

As a result of the statistical interpretation of the data, it was found that the mean dynamic form factor for potash aerosol is 7.5. The apparent density is 320 kg/m^3 (the true density is 2400 kg/m^3). The mean equivalent radius is 1.02 microns. The integral curve of the distribution of potash dust particles based on equivalent radii (from the data of count concentration) is presented in Fig. 4 in a probability system of coordinates.

As a result of studying the dispersion composition of potash aerosol, the effect of electrostatic charges on particles was established as a well-

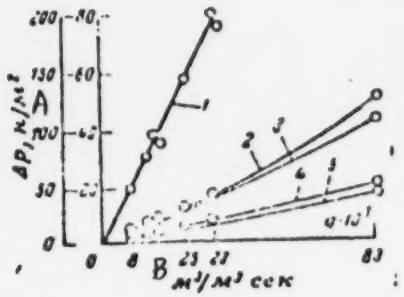

Fig. 3. Plots of the dependence of the hydraulic drag of filter cloth on the gas filtration load 1 -- TSSNP-O glass cloth (the first pressure scale pertains only to glass cloth); 2 -- ChSh baize; 3 -- lavsan; 4 -- nitron 408; 5 -- serge weave 2 x 2 nitron.

KEY: A -- N/m^2

B -- m^3/m^2 . sec

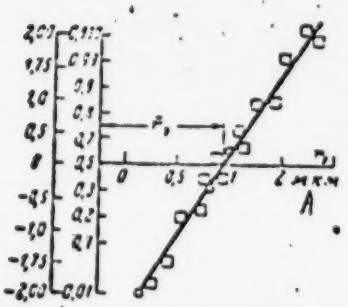

Fig. 4. Integral curve of the distribution of potash particles in a probability system of coordinates

KEY: A -- Microns

defined function of their aggregation and aggregate structure. In the absence of electrostatic charges, particles aggregate in bodies of spherical shape. When particles are charged, owing to the specific details of the operation of a unit, the particles can obtain a charge; they coagulate in aggregates with acicular form, with considerable predominance of length over thickness.

Considering that the nonuniformity of cloth density (textile seconds) strongly affects collection efficiency and the strength of filter bags, the hydraulic drag of cloth samples from which the bags were sewn was measured at eight-twelve points. The mean-square root drag values calculated by the formula $(\sum_i \Delta p_i^2/n_i)^{0.5}$ was taken as the true values, from which then the function shown in Fig. 3 was plotted. The deviation of the drag values of the sections investigated must not exceed 10-12 percent for good filter cloth.

The amount of gas and its flow rate over the gas duct section was calculated based on the dynamic head measured with the NIIOGAZ pneumometric tube and a MMN-1 micromanometer. The mean gas flow rate in the gas duct from which the volume of gas was calculated was found as the arithmetic mean of the gas velocities at points of measurement along two mutually perpendicular sections of the gas duct.

The gas moisture content was measured psychrometrically based on the difference between the temperatures of a dry and a wet thermometer. The moisture content of the gas varies with the limits of 0.28-0.37 kg/m^3 of dry gas under normal conditions. Changes in moisture content are accounted for by the different metering rates of the aqueous solution of the ionizing additive.

A	B	C	D	E	F
Температура газа, °С	Концентрация пыли, г/м³, в нормальных условиях	Разрежение, кН/м²	Сопротивление фильтра, кН/м²	Нагрузка по газу фильтрования, м³/м²·сек	Степень улавливания, %
	G Байка ЧШ				
116/66	7,62/—	22,8/37,3	11,7	10,0	—
120/68	7,65/0,745	24,0/37,0	11,1	10,0	91,6
125/70	2,19/0,406	25,8/37,5	11,1	10,0	80,0
92/56	7,65/0,765	53,7/62,0	8,5	12,0	90,0
90/54	5,83/0,530	20,0/27,4	6,3	12,0	91,1
108*/63*	6,193*/0,611*	—	—	—	83,2*
	H Нитрон саржевого переплетения 2×2				
125/72	7,20/1,19	30,6/41,7	11,3	10,0	84,0
185/118	5,97/0,682	27,8/39,2	10,2	10,0	89,0
193/122	5,26/0,756	30,6/40,2	11,1	10,0	86,0
55/35	6,55/0,530	20,0/27,0	6,3	12,0	92,0
65/40	5,92/0,675	20,5/28,0	7,05	12,0	89,0
	I Стеклоткань ТССНФ-О				
89/70	8,83/0,630	31,4/40,1	8,7	18,0	99,4
110/83	8,35/0,632	42,4/47,2	7,1	12,0	99,7
168/111	7,17/0,629	24,7/27,3	2,9	10,0	99,7
169/115	4,47/0,031	21,2/23,15	1,73	4,1	99,1
216/163	4,4/0,035	52,5/56,4	4,1	20,1	99,87
190/155	1,4/0,008	61,4/63,1	2,9	15,0	99,51
155*/103*	5,77*/0,026*	—	4,33	—	99,6*

KEY: A -- Gas temperature

B — Dust concentration, g/m^3, in normal conditions

C -- Rarefaction, kN/m^2

D -- Filter drag, kN/m^2

E -- Gas load on filtration, $q \cdot 10^3$, $m^3/m^2 \cdot sec$

F — Collection efficiency

G -- ChSh baize

H -- Serge weave 2 x 2 nitron

I -- TSSNF-O glass cloth

* Mean values.

Remark. The numerator refers to the parameter at the filter inlet, and the denominator -- at the outlet.

As we can see from the table where the composite results of operating regimes and dust collection efficiency in the bag filter are presented, ChSh baize and nitron do not afford the required degree of purification. The residual dust content varied from 0.406 to 0.745 g/m^3 in normal conditions for a gas filtration load of $10^{-2} m^3/m^2 \cdot sec$ (0.56 $m^3/m^2 \cdot min$), and from 0.530 to 0.765 g/m^3 in normal conditions for a load of $1.2 \cdot 10^{-2} m^3/m^2 \cdot sec$ (0.71 $m^3/m^2 \cdot min$). The collection efficiency for ChSh baize bags varied within the limits 80-91.6 percent.

The dust collection efficiency in a bag filter made of nitron bags was somewhat higher than for ChSh baize bags and varied within the limits 84-92 percent for loads of $(1-1.2) \cdot 10^{-2} m^3/m^2 \cdot sec$.

The variation in the dust concentration at the bag filter inlet within the limits 2.19-7.65 g/m^3 in normal conditions is accounted for by the variation in the amount of ionizing additive.

The hydraulic drag of bags made of ChSh baize and nitron was quite high, and depending on load, varied within the limits 6.3-11.7 kN/m^2.

Cloth regeneration was carried out by reverse blowing of purified gas with a load of $5 \cdot 10^{-3}$ $m^3/m^2 \cdot sec$ (0.3 $m^3/m^2 \cdot min$) and was wholly satisfactory, affording stable filter operation. The hydraulic drag after regeneration was reduced by an average from 11 to 2.6-3.7 kN/m^2.

A brief rise in the gas temperature at the inlet to the bag filter, equipped with nitron bags, to 200° C had no detrimental effect on the strength and filtering abilities of the cloth.

Glass-cloth bags were investigated for different temperatures of gas at the apparatus inlet (89-216° C) and for filtration rates from $4.1 \cdot 10^{-3}$ to $2.0 \cdot 10^{-2}$ m/sec (for gas filtration loads from 0.25 to 1.24 $m^3/m^2 \cdot min$).

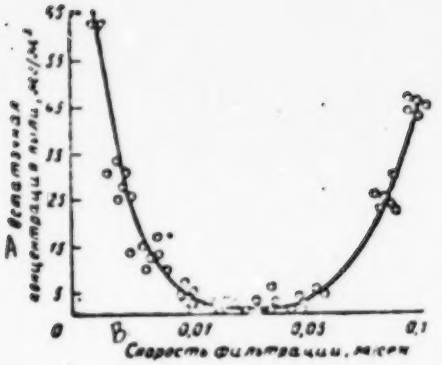

Fig. 5. Curve of the filtration rate dependence of residual dust concentration

KEY: A — Residual dust concentration, $мг/м^3$

B — Filtration rate, m/sec

Analysis of these results showed that the filtration of gas with a low gas temperature at the apparatus inlet (90° C) leads to an abrupt increase in the hydraulic drag of the dust layer and considerably increases the breakthrough of highly dispersed particles (residual dust concentration in this case was 0.05 $г/м^3$ in normal conditions). This is accounted for by the disruption of the filtering layer with partial condensation, since potash is highly hygroscopic, and the moisture content of the gas is high (dew point 80° C). As the gas temperature at the apparatus inlet is increased, the residual dust concentration drops off markedly, reaching a level of 0.006-0.008 $г/м^3$ in normal conditions at temperatures of 190-216° C, respectively.

We must note that the variation in the dust concentration at the bag filter inlet within the limits from 1.4 to 8.35 $г/м^3$ in normal conditions and the variation in the filtration rate from $4.1 \cdot 10^{-3}$ to $2.0 \cdot 10^{-2}$ m/sec has practically no substantial effect on the residual dust concentration.

For example, for extended operation of a bag filter with a gas filtration load of $2 \cdot 10^{-3}$ $m^3/m^2 \cdot sec$ and an inlet dust concentration of 4.4 g/m^3 in normal conditions, stable filter operation in purifying gas free of dust down to a residual concentration of 0.006 g/m^3 in normal conditions was achieved.

The collection efficiency reached a level of 99.7-99.9 percent, where the inlet dust concentration was 1.4-8.35 g/m^3 at a filtration rate measured within the limits from $4.1 \cdot 10^{-3}$ to $2.0 \cdot 10^{-2}$ m/sec.

As we can see from Fig. 5, in the filtration range from 0.01 to 0.05 m/sec the maximum degree of gas purification was achieved. At filtration rates below 0.01 m/sec and above 0.05 m/sec, the degree of purification drops off and the residual dust concentration rises. This is accounted for by the fact that in filtering gases containing particles greater than 0.2 microns in diameter, the inertial mechanism of collection predominates over the diffusional.

Depending on the period between filter cloth regenerations, the hydraulic drag of the filter varied within the limits 1.73 to 8.7 kN/m^2 (170-860 mm H_2O). A study was made of the operation of the filter with hydraulic drag values up to 24-27 kN/m^2 (2400-2700 mm H_2O). However, even a drag value this high had no destructive effect on the structure, density, and strength of the glass cloth — filter performance was satisfactory and dust breakthrough did not increase.

Extended residence of glass cloth in a strong alkaline medium (approximately a year) had no substantial effect on its strength and filtering qualities. After a six-month operating period and threefold washing with water, the strength of the glass cloth in a bag filter remained practically unchanged. At the same time, in nonframe bags glass cloth

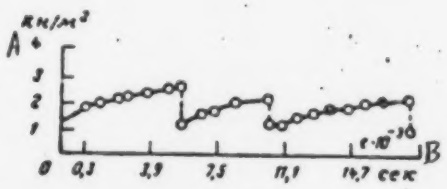

Fig. 6. Plot of the dependence of hydraulic drag of TSSNF-O glass cloth on its dust-filling time

KEY: A -- kN/m^2

B -- sec

failed after 1.5 months of operation. The residual dust content in the same filtration conditions in nonframe bags was much higher, 80-150 mg/m^3 in normal conditions.

As we can see from Fig. 6, the residual drag of cloth after regeneration was maintained within the limits 105-180 N/m^2 (10.4-17.8 mm H_2O). The period between regenerations varied from $1.8 \cdot 10^3$ to $7.2 \cdot 10^3$ seconds (30-60 minutes).

Conclusions

1. Studies showed that fine purification of gas from highly dispersed particles down to a residual concentration of 0.006-0.008 g/m^3 in normal conditions can be obtained in bag filters equipped with glass cloth bags in filtering gas at temperatures up to 190-215° C. The collection efficiency is 99.5-99.9 percent. With a reduction in the temperature of the gas to be filtered, the residual dust concentration is increased to 0.029-0.050 g/m^3 in normal conditions, while the collection efficiency is reduced down to 99.4-99.7 percent.

2. Cloth regeneration is achieved only by reverse blowing with a blowing gas load within the limits $(1-5) \cdot 10^{-2}$ $m^3/m^2 \cdot sec$.

3 Gas can be purified in bag filters at even higher hydraulic drag values and higher filtration rates without detriment to strength and filtering qualities of the cloth.

4. These results can be used in designing systems of fine purification of air from dust at central coal-pulverizing mills.

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